

CALIFORNIA
AGRICULTURAL EXTENSION SERVICE

CIRCULAR 125

October, 1942

IRRIGATED PASTURES IN
CALIFORNIA

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Beef cattle on irrigated pasture.

Coöperative Extension work in Agriculture and Home Economics, College of Agriculture,
University of California, and United States Department of Agriculture coöperating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
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THE COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

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IRRIGATED PASTURES IN CALIFORNIA¹

BURLE J. JONES² AND J. B. BROWN³

INTRODUCTION

AN IRRIGATED PASTURE is an area in which the pasturing of livestock is of prime importance, not secondary to a crop of hay. Frequently, however, an irrigated pasture may be clipped for a cutting of hay, or to reduce weeds or coarse clumps about the droppings of cattle. It is now usually



Fig. 1.—Good utilization of Ladino clover and grass pasture by dairy cattle.

made up of a mixture of perennial grasses and legumes (fig. 1). Sometimes a legume, such as Ladino clover or alfalfa, is seeded alone; and occasionally only a grass, such as Dallis, is seeded. But the recommendations are usually for a mixture of legume and grass species.

Irrigated pastures began to find a place in California in the early 1930's. A survey made by county farm advisors showed that the acreage had reached a total of about 200,000 in the state by January, 1941, and this is being rapidly expanded. Because of the shallow rooting habits of the plants used, as compared with alfalfa, irrigated pastures occupy primarily those areas not suited to alfalfa. There are many farms, however, where land well adapted to alfalfa has been seeded to pasture in order to balance the livestock operations between winter and summer feed requirements. The chief function of such pastures is to reduce the

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total annual cost of feeds by requiring the farm livestock to harvest their own feed during the growing season.

Where alfalfa diseases are prevalent and greatly reduce the life of stands, it is a common practice to seed grasses and legumes in depleted alfalfa stands. This is particularly true in the San Joaquin Valley, where there is a considerable sag in the growth of Ladino clover during mid-summer and where alfalfa will provide a legume in the pasture that will grow vigorously during that period.

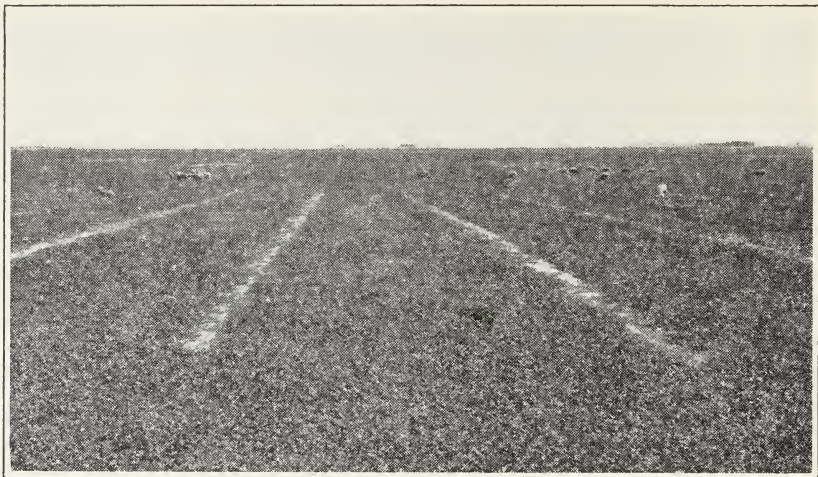


Fig. 2.—Irrigated pasture of Ladino clover and grass, showing a full and even utilization of feed by sheep. Compare with figure 3.

Irrigated pastures occupy a minor but increasingly important place as a rotation crop with rice. It has recently been estimated that 8,000 acres of rice land (out of a total of 120,000) are in a rotation crop of irrigated pasture.

Irrigated pastures have not entered into common farm practice in the highly productive and high-priced lands contributing to some of our larger milk sheds. But test plantings in such counties as Orange, Riverside, and Los Angeles have demonstrated that, on lands where seepage losses are not too high, such pastures actually effect a marked saving in feed costs over the customary practice of feeding green (clipped) alfalfa, or alfalfa hay, and concentrates.

Some of the large-scale sheep and beef-cattle raisers are finding irrigated pastures profitable in some phase of their operations. Such pastures may be utilized in the maintenance of a breeding herd, in providing suitable feed for weaner calves or lambs, or in fattening for market. The Oakdale district in Stanislaus County, for example, has recently

acquired considerable fame in fattening lambs on irrigated pastures (fig. 2).

There are certain standards or yardsticks that can be used as guides to determine what objectives a prospective pasture user should seek to attain and the means by which he may reach them economically. It is the purpose of this circular to indicate those objectives and the steps by which they may be accomplished, as these factors have been determined by experience in the various irrigated sections of the state.



Fig. 3.—A pasture of Ladino clover and ryegrass. The grass is approaching maturity, and heavier stocking is essential to reduce it before it becomes too mature. Compare with figure 2.

PRIMARY CONSIDERATIONS

Before embarking on an irrigated-pasture project, several points should be given careful consideration.

Soil and Climatic Adaptation.—Probably the first consideration should be the adaptation of the site to an irrigated pasture or to a particular mixture of species. This may be difficult to determine if there are no examples on similar sites that can be used as a guide. Some mixture can be found that will grow on almost any soil where sufficient irrigation water is available to meet the requirements of growing plants during the dry summer. The roots of Ladino clover, which is the basic legume in most of the irrigated pastures in this state, extract little or no plant nutrients from depths below the first foot of soil, and most of the grasses sown with it can survive on a foot of soil, though many of them prefer to strike much deeper. This means that very shallow soils may be utilized. But soil or climatic conditions may be such that profitable production is not possible. On some soils a good growth of Ladino cannot be economically attained, apparently because of inadequate supplies of phos-

phorus; and added phosphorus is fixed in these soils so rapidly that it is not available to the plants. In very sandy soils, moisture in the top foot may be depleted too rapidly to allow economic pasture production. Ladino tends to show a decline in summer growth as temperatures increase. This begins to evidence itself in the southern end of the San Joaquin Valley. In the Imperial and Palo Verde valleys it is not generally considered as a satisfactory legume for pasture use.

Adaptability to the Farm Program.—Another important consideration is fitting an irrigated pasture into the general farm program. This has to do with the size of farm, the kind of livestock to be fed, and the necessary balance of year-round feed supplies in terms of hay, concentrates, and pasture. On most farms it will be essential to have adequate hay, and possibly silage and concentrate supplies for the winter months. It will also be very desirable to have sufficient pasture acreage so that a satisfactory plan of rotation grazing can be applied—unless only part-time use of the pasture can be managed.

On many livestock farms it may be desirable to grow irrigated pastures for special uses, such as the breeding herd or flock, the care of weanlings, or for fattening, while the other animals are continued in the practices formerly used.

Costs.—Costs must be thoroughly considered in terms of soil preparation and the maintenance and overhead costs that will follow. Here alfalfa is a good yardstick by which to measure probable costs and potential results. If the topography of the land is such that it could be profitably graded for alfalfa, on the basis of average returns, and if water costs would not be prohibitive for alfalfa, then it is likely to be profitable to put in an irrigated pasture if the soil and climatic factors are not adverse.

The actual cost of preparation, seeding, and maintenance will vary markedly with the topography of the soil, water costs, taxes, and upkeep of irrigation structures. Several sets of figures have come out of pasture cost account studies and are given in another section so that they may be used as a guide to this phase of the problem.

Production.—Because alfalfa is a somewhat competitive crop upon which profitable yields and prevalent practices are generally known, it is convenient to compare irrigated pastures with alfalfa. Thus an irrigated pasture should yield as large a tonnage per acre as alfalfa and should require no greater total irrigation water, or labor. In other words, irrigated pasture should parallel alfalfa in production and cost items, and should be more economical by the margin of harvesting and feeding costs since these are performed by the farm animals themselves when on

pasture. There will be exceptions, which will be pointed out elsewhere, but in general this is a fair comparison. As has been stated, irrigated pastures will thrive on many shallow soils that are not suitable for the production of alfalfa. Even there, unless some adverse condition prevails, the annual production should equal the average of alfalfa when the latter is grown on soils reasonably suited to it.

Production should be gauged, not by the returns of a single season, but by the average for several years. In the case of alfalfa, producers are almost constantly in touch with the crop in the course of irrigation and harvesting operations, and the harvesting itself furnishes a rather accurate record of annual yields. With pastures, on the contrary, operators have been too prone to neglect the observations and corrections that are essential to maintenance of high yields. Weeds may creep in, the composition of the mixture may change, or the total yield may decline without the operator's being aware of the changes. Cost studies in some counties indicated that the average production of irrigated pastures is declining. But they also indicate that some pastures continue to have a higher carrying capacity than others on similar sites. It is in the hope of emphasizing the causes of these variations that the subject of pasture management is especially stressed in this circular.

Production in terms of animal units per acre per year will vary markedly with certain fixed soil, climatic, and irrigation limitations that are beyond the control of a prospective operator. They should all be taken into account in determining if an irrigated pasture is economically sound. Once the pasture is established, the operator should so regulate his management practices as to maintain high production. There are few cases on record in California where the carrying capacity falls below 1 animal unit (1 mature cow) per acre for the grazing season (8 to 11 months). There are reports of carrying capacities as high as 2 and even 3 animal units per acre for the season. A capacity of 2 animal units per acre is not excessive for the great bulk of the acreage in this state if the mixture and stand are adequate and the proper management is applied.

Improvement in Livestock and Income.—Livestock improvement begins with a well planned and properly executed breeding program. Next in importance is adequate feed supplies. For the dairyman a good irrigated pasture, grazed at the right stage of growth for maximum nutritive values, has been demonstrated to produce more milk than does hay, or even hay and concentrates. And the saving in the cost of harvesting and feeding often means the difference between profit and loss.

With irrigated pastures the range operator may increase both the quantity and the quality of his output, through better gains in young

stock, a higher production in the breeding herd, and higher weights and finer finish in the market animals. While he may be substituting higher-priced feeds for range forage, he will effect a saving in supplements. The whole operation, when properly designed and executed, should result in a more profitable and satisfactory enterprise.

MIXTURES

General-Purpose Mixtures.—Legume and grass mixtures recommended by county farm advisors are given below. These may be considered as general-purpose mixtures for cattle and sheep. They are based on local experience in areas of demonstrated adaptations and costs and do not cover unusual soil, climatic, moisture, elevation, or topographic sites.

County	General-purpose mixture and amounts per acre
Alameda	Ladino clover, 5 lbs.; Domestic ryegrass, 5 lbs.; and orchard grass, 5 lbs.; total, 15 lbs.
Butte	Ladino clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 4 lbs.; total, 12 lbs.; occasionally added: alfalfa, 2 lbs.; or Dallis grass, 4 lbs.; or both
Colusa	Ladino clover, 4 lbs.; Domestic ryegrass, 2 lbs.; and orchard grass, 4 lbs.; total, 10 lbs.; occasionally added: alfalfa, 4 lbs.
Contra Costa	Ladino clover, 4 lbs.; Domestic ryegrass, 6 lbs.; and orchard grass, 4 lbs.; total, 14 lbs.; occasionally added: Dallis grass, 4 lbs.
El Dorado	Ladino clover, 4 lbs.; Domestic ryegrass, 6 lbs.; and Dallis grass, 6 lbs.; total, 16 lbs.
Fresno	Ladino clover, 4 lbs.; alfalfa, 3 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 4 lbs.; orchard grass, 4 lbs.; and Dallis grass, 4 lbs.; total, 22 lbs.; occasionally added: alsike clover, 1 lb.; meadow fescue, 2 lbs.; Harding grass, 2 lbs.; or Kentucky bluegrass, 1 lb.; or two or more of these
Humboldt	Ladino clover, 5 lbs.; Domestic ryegrass, 15 lbs.; total 20 lbs.; occasionally added: alfalfa, 20 lbs.; or alsike clover, 10 lbs.; or both
Kern	Ladino clover, 4 lbs.; alfalfa, 3 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 3 lbs.; orchard grass, 3 lbs.; and Dallis grass, 3 lbs.; total, 19 lbs.
Kings	Ladino clover, 3 lbs.; alfalfa, 4 lbs.; bur clover, 5 lbs.; Domestic ryegrass, 5 lbs.; and orchard grass, 5 lbs.; total, 22 lbs.; occasionally added: Dallis grass, 5 lbs.
Lake	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; Domestic ryegrass, 2 lbs.; perennial ryegrass, 3 lbs.; orchard grass, 4 lbs.; meadow fescue, 3 lbs.; and Harding grass, 2 lbs.; total 20 lbs.

County	General-purpose mixture and amounts per acre
Lassen	Alfalfa, 5 lbs.; perennial ryegrass, 5 lbs.; smooth brome, 6 lbs.; and tall oatgrass, 4 lbs.; total, 20 lbs.; occasionally added: alsike clover, 4 lbs.; or yellow sweet clover, 5 lbs.; or both
Los Angeles	Ladino clover, 4 lbs.; bur clover, 4 lbs.; Domestic ryegrass, 2 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 4 lbs.; and Dallis grass, 2 lbs.; total, 18 lbs.; occasionally added: alfalfa, 4 lbs.
Madera	Ladino clover, 4 lbs.; alfalfa, 3 lbs.; bur clover, 2 lbs.; Domestic ryegrass, 2 lbs.; orchard grass, 2 lbs.; meadow fescue, 2 lbs.; Harding grass, 2 lbs.; Dallis grass, 2 lbs.; and Kentucky bluegrass, 1 lb.; total, 20 lbs.
Mendocino	Ladino clover, 4 lbs.; perennial ryegrass, 8 lbs.; orchard grass, 4 lbs.; and Harding grass, 2 lbs.; total, 18 lbs.
Merced	Ladino clover, 3 lbs.; alfalfa, 3 lbs.; perennial ryegrass, 6 lbs.; orchard grass, 3 lbs.; Kentucky bluegrass, 3 lbs.; and bird's-foot trefoil, 1 lb.; total, 19 lbs.
Modoc	Alsike clover, 2 lbs.; perennial ryegrass, 5 lbs.; orchard grass, 6 lbs.; meadow fescue, 6 lbs.; and red clover, 2 lbs.; total, 21 lbs.
Monterey	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 3 lbs.; orchard grass, 3 lbs.; and tall oatgrass, 3 lbs.; total, 18 lbs.
Napa	Ladino clover, 4 lbs.
Orange	Ladino clover, 4 lbs.; alfalfa, 4 lbs.; Domestic ryegrass, 3 lbs.; perennial ryegrass, 3 lbs.; orchard grass, 3 lbs.; Harding grass, 2 lbs.; and Dallis grass, 3 lbs.; total, 22 lbs.
Placer	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; and Domestic ryegrass, 4 lbs.; total, 10 lbs.; occasionally added: Dallis grass, 2 lbs.
Riverside	Ladino clover, 3 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 1 lb.; perennial ryegrass, 3 lbs.; orchard grass, 3 lbs.; meadow fescue, 3 lbs.; and Dallis grass, 3 lbs.; total, 19 lbs.
Sacramento	Ladino clover, 4 lbs.; and Domestic ryegrass, 5 lbs.; total, 9 lbs.; occasionally added: orchard grass, 5 lbs.; or Dallis grass, 5 lbs.; or both
San Benito	Alfalfa, 2 lbs.; alsike clover, 1 lb.; bur clover, 1 lb.; yellow sweet clover, 2 lbs.; Domestic ryegrass, 2 lbs.; orchard grass, 2 lbs.; Harding grass, 2 lbs.; and Dallis grass, 2 lbs.; total, 14 lbs.
San Bernardino	Ladino clover, 3 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 3 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 3 lbs.; meadow fescue, 2 lbs.; and Dallis grass, 3 lbs.; total, 19 lbs.; occasionally added: alfalfa, 3 lbs.
San Diego	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; Domestic ryegrass, 4 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 4 lbs.; Harding grass, 2 lbs.; and Dallis grass, 2 lbs.; total, 20 lbs.

County	General-purpose mixture and amounts per acre
San Joaquin	Ladino clover, 3 lbs.; Domestic ryegrass, 2 lbs.; orchard grass, 4 lbs.; meadow fescue, 2 lbs.; and Harding grass, 2 lbs.; total, 13 lbs.; occasionally added: alfalfa, 2 lbs.
San Luis Obispo	Ladino clover, 4 lbs.; yellow sweet clover, 4 lbs.; Domestic ryegrass, 6 lbs.; and orchard grass, 3 lbs.; total, 17 lbs.; occasionally added: alfalfa, 5 lbs.; meadow fescue, 4 lbs.; or, Dallis grass, 4 lbs.; or two or more of these
Santa Barbara	Ladino clover, 4 lbs.; Domestic ryegrass, 8 lbs.; orchard grass, 4 lbs.; and meadow fescue, 4 lbs.; total, 20 lbs.; occasionally added: alfalfa, 3 lbs.; or Harding grass, 1 lb.; or both
Santa Cruz	Ladino clover, 5 lbs.; Domestic ryegrass, 8 lbs.; orchard grass, 4 lbs.; and meadow fescue, 3 lbs.; total, 20 lbs.; occasionally added: bur clover, 2 lbs.
Shasta	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 5 lbs.; total, 15 lbs.; occasionally added: alsike clover, 3 lbs.
Siskiyou	Ladino clover, 4 lbs.; Domestic ryegrass, 4 lbs.; orchard grass, 4 lbs.; and smooth brome, 4 lbs.; total, 16 lbs.
Sonoma	Ladino clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 2 lbs.; total, 10 lbs.
Solano	Ladino clover, 5 lbs.; occasionally added: Domestic ryegrass, 6 lbs.
Stanislaus	Ladino clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 4 lbs.; total, 12 lbs.; occasionally added: alfalfa, 4 lbs.; perennial ryegrass, 4 lbs.; or Kentucky bluegrass, 4 lbs.; or two or more of these
Sutter	Ladino clover, 4 lbs.; alfalfa, 2 lbs.; Domestic ryegrass, 4 lbs.; and Dallis grass, 4 lbs.; total, 14 lbs.; occasionally added: orchard grass, 4 lbs.
Tehama	Ladino clover, 4 lbs.; Domestic ryegrass, 5 lbs.; and Dallis grass, 2 lbs.; total, 11 lbs.; occasionally added: alfalfa, 3 lbs.; or orchard grass, 3 lbs.; or both
Tulare	Ladino clover, 4 lbs.; bur clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 5 lbs.; total, 17 lbs.; occasionally added: Dallis grass, 5 lbs.
Ventura	Ladino clover, 4 lbs.; alfalfa, 4 lbs.; Domestic ryegrass, 8 lbs.; orchard grass, 4 lbs.; and Harding grass, 4 lbs.; total, 24 lbs.
Yolo	Ladino clover, 4 lbs.
Yuba	Ladino clover, 4 lbs.; Domestic ryegrass, 8 lbs.; and orchard grass, 4 lbs.; total, 16 lbs.
Palo Verde and Coachella valleys ..	Alfalfa, 5 lbs.; bur clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and Dallis grass, 6 lbs.; total, 19 lbs.

These recommendations show several interesting trends:

1. Recommendations for the southern part of the state show a larger poundage of seed used and a greater number of species. This is probably because more species are required to produce growth through the longer pasture season of that district.

2. Bur clover is generally included in the mixture in the southern counties. In that area bur clover grows during the winter months and thus supplies a legume at that time.

3. A light seeding of alfalfa is generally advised in the San Joaquin Valley and, to a lesser degree, in other warm areas. This is to provide a legume during the hotter months when there is a slight sag in the growth of Ladino clover.

4. Ladino clover ranks first in popularity, being recommended in 37 of the 40 counties tabulated. Domestic ryegrass is second, orchard grass third, alfalfa fourth, and Dallis grass fifth. These five, then, might be assumed to constitute a standard mixture in any area to which they are all adapted.

With cattle and sheep, grazing preferences should be balanced with bloat hazard.⁴ When grasses predominate in the mixture, the animals tend to crop the legumes closely, and conversely they search for grasses and the coarser material when the pasture is largely clover. In Australia, where this matter has been studied carefully, 40 to 50 per cent clover has been found to meet the grazing preference of cattle and sheep with a minimum of bloat hazard.

While most of the perennial grasses may be kept green throughout much of the grazing season by pasturing and irrigation, they do have a preferred season for growth and ripening. Thus domestic ryegrass is the earliest we now have in growth and natural maturity. It tends to become semidormant, even under irrigation, by midsummer. English ryegrass is somewhat later and more persistent in growth habit. Orchard grass, meadow fescue, and tall fescue are midseason grasses, while redtop grass and timothy are late. Harding is the latest of all and in the warmer sections of the state is practically winter-growing.

Special Mixtures.—In some counties the farm advisors have issued recommendations for pasture mixtures for horses and hogs and for certain unusual soil conditions. These are given below. For situations not covered by these tabulations, it would be best to consult the local county farm advisor.

⁴ For suggestions on prevention of bloat by the inclusion of fiber in the diet, see: Cole, H. H., S. W. Mead, and Max Kleiber. Bloat in cattle. California Agr. Exp. Sta. Bul. 662:1-22. 1942.

Purpose and county Special mixture and amounts per acre

For hogs:

Butte Ladino clover, 7 lbs.
 Kern Ladino clover, 4 lbs.; and alfalfa, 4 lbs.
 Kings Ladino clover, 3 lbs.; alfalfa, 4 lbs.; and bur clover, 5 lbs.
 Madera Ladino clover, 4 lbs.; alfalfa, 4 lbs.; and bur clover, 4 lbs.
 Merced Ladino clover, 4 lbs.; and alfalfa, 4 lbs.
 Placer Ladino clover, 4 lbs.; and alfalfa, 2 lbs.
 San Luis Obispo ... Ladino clover, 4 lbs.; yellow sweet clover, 4 lbs.; Domestic ryegrass, 6 lbs.; orchard grass, 3 lbs.; and Dallis grass, 4 lbs.

For horses:

Madera Ladino clover, 4 lbs.; alfalfa, 3 lbs.; bur clover, 2 lbs.; Domestic ryegrass, 2 lbs.; orchard grass, 2 lbs.; meadow fescue, 2 lbs.; Harding grass, 2 lbs.; Dallis grass, 2 lbs.; and Kentucky bluegrass, 2 lbs.
 Santa Cruz Ladino clover, 3 lbs.; bur clover, 2 lbs.; Domestic ryegrass, 7 lbs.; orchard grass, 4 lbs.; and meadow fescue, 3 lbs.

On alkali land:

Contra Costa Ladino clover, 2 lbs.; alfalfa, 1 lb.; bird's-foot trefoil, 1 lb.; Domestic ryegrass, 4 lbs.; orchard grass, 2 lbs.; Dallis grass, 1 lb.; and Rhodes grass, 1 lb.
 Madera Alfalfa, 4 lbs.; yellow sweet clover, 3 lbs.; strawberry clover, 2 lbs.; Domestic ryegrass, 3 lbs.; Dallis grass, 2 lbs.; and Rhodes grass, 4 lbs.
 Merced Yellow sweet clover, 5 lbs.; strawberry clover, 2 lbs.; bird's-foot trefoil, 2 lbs.; Dallis grass, 5 lbs.; and Rhodes grass, 2 lbs.
 Modoc Strawberry clover, 3 lbs.; smooth brome, 4 lbs.; redtop grass, 3 lbs.; white sweet clover, 3 lbs.; western wheatgrass, 5 lbs.; and Lemmon alkali grass, 2 lbs.
 Orange Yellow sweet clover, 6 lbs.; strawberry clover, 4 lbs.; Dallis grass, 4 lbs.; and Rhodes grass, 6 lbs.
 San Benito Alsike clover, 1 lb.; bur clover, 1 lb.; yellow sweet clover, 2 lbs.; strawberry clover, 1 lb.; Domestic ryegrass, 5 lbs.; orchard grass, 2 lbs.; meadow fescue, 2 lbs.; and Rhodes grass, 2 lbs.
 San Bernardino ... Alfalfa, 2 lbs.; yellow sweet clover, 4 lbs.; Domestic ryegrass, 4 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 3 lbs.; meadow fescue, 2 lbs.; and Dallis grass, 2 lbs.
 San Diego Strawberry clover, 3 lbs.; and Rhodes grass, 6 lbs.
 San Joaquin Strawberry clover, 3 lbs.; and Rhodes grass, 6 lbs.
 Shasta Alsike clover, 3 lbs.; strawberry clover, 4 lbs.; orchard grass, 5 lbs.; and redtop grass, 3 lbs.

Purpose and county	Special mixture and amounts per acre
On light, sandy soil:	
Madera	Alfalfa, 6 lbs.; yellow sweet clover, 3 lbs.; orchard grass, 3 lbs.; Harding grass, 3 lbs.; and Dallis grass, 3 lbs.
Merced	Alfalfa, 4 lbs.; yellow sweet clover, 4 lbs.; bird's-foot trefoil, 2 lbs.; perennial ryegrass, 6 lbs.; Dallis grass, 6 lbs.; and Kentucky bluegrass, 3 lbs.
San Bernardino ...	Alfalfa, 3 lbs.; bur clover, 3 lbs.; Domestic ryegrass, 3 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 3 lbs.; meadow fescue, 2 lbs.; and Dallis grass, 3 lbs.
San Diego	Alfalfa, 4 lbs.; bur clover, 2 lbs.; Domestic ryegrass, 4 lbs.; perennial ryegrass, 2 lbs.; orchard grass, 2 lbs.; and Harding grass, 4 lbs.
Stanislaus	Ladino clover, 2 lbs.; alfalfa, 4 lbs.; yellow sweet clover, 6 lbs.; Domestic ryegrass, 4 lbs.; and orchard grass, 4 lbs.
Tulare	Ladino clover, 4 lbs.; bur clover, 4 lbs.; Domestic ryegrass, 4 lbs.; and Dallis grass, 5 lbs.
On marsh lands:	
Merced	Strawberry clover, 2 lbs.; bird's-foot trefoil, 2 lbs.; perennial ryegrass, 4 lbs.; and Dallis grass, 5 lbs.
Modoc	Alsike clover, 3 lbs.; and Reed canary grass, 6 lbs.
Monterey	Ladino clover, 3 lbs.; strawberry clover, 2 lbs.; orchard grass, 5 lbs.; Dallis grass, 3 lbs.; and Reed canary grass, 5 lbs.
San Benito	Yellow sweet clover, 2 lbs.; strawberry clover, 1 lb.; Domestic ryegrass, 8 lbs.; Dallis grass, 2 lbs.; and redtop grass, 2 lbs.
San Joaquin	Ladino clover, 3 lbs.; Domestic ryegrass, 2 lbs.; orchard grass, 4 lbs.; meadow fescue, 2 lbs.; and Reed canary grass, 4 lbs.
Shasta	Ladino clover, 4 lbs.; alsike clover, 3 lbs.; orchard grass, 5 lbs.; and redtop grass, 3 lbs.
Siskiyou	Alsike clover, 4 lbs.; strawberry clover, 2 lbs.; orchard grass, 6 lbs.; redtop grass, 4 lbs.; and timothy, 4 lbs.
On summer-dry meadows:	
Lassen	Alfalfa, 4 lbs.; yellow sweet clover, 5 lbs.; smooth brome, 10 lbs.; crested wheatgrass, 5 lbs.
Mendocino	Perennial ryegrass, 8 lbs.; orchard grass, 4 lbs.; and redtop grass, 4 lbs.

Where a pasture is to be used exclusively for hogs, only a legume need be seeded (fig. 4). Hogs will consume a limited amount of succulent grasses, but their needs are adequately cared for by legume forage and there is danger that any grasses in the mixture will be neglected and will become coarse and lignous, and the carrying capacity of the pasture be cut down.

Horses, on the other hand, prefer rather coarse stemmy grasses for the major portion of their grazing ration. From 10 to 20 per cent of legumes would meet their requirements.

LAND PREPARATION AND IRRIGATION

The main objective of land preparation is to bring about the most economic and uniform application of irrigation water. The layout will vary with the system of irrigation chosen. The final step in land preparation is to prepare a proper seedbed. This is discussed in connection with seeding on page 23.

The principles of irrigation for pasture crops are no different than for the irrigation of other crops. The object is to maintain an adequate supply of water for the plant at all times.



Fig. 4.—A pasture of pure Ladino clover, just beginning to bloom. Pure Ladino is ideal for hogs, but the bloat hazard is high for cattle and sheep.

Many forage crops used in irrigated pastures are relatively shallow-rooted, some decidedly so. This shallow rooting increases the frequency of water application because it is impossible to store enough water in such limited depths to supply transpiration needs of plants. Studies indicate that the monthly water use by forage crops will vary between 4 inches and 8 inches in depth, the amount depending on climatic factors.

Pastures are irrigated by strip checks, contour checks, wild flooding, or sprinkling. The factors to be considered in selecting the method are soil type, topography, and flow of water available.

Soil Types and Characteristics.—The amount of water readily available to plants is determined by the physical characteristics of the soil occupied by the roots. Between the field capacity and the permanent wilting percentage, water appears to be equally available at all times. "Field capacity" is defined as the amount of water (expressed as a per-

centage of dry weight of soil) which will be retained against the downward pull of gravity. "Permanent wilting percentage" is the amount of water remaining in the soil when plants wilt. The "water yield" of any soil is the difference between field capacity and permanent wilting percentage. These moisture properties of soils depend on soil texture. Coarse-textured soils, such as sands, have low water-yielding properties, while fine-textured soils, such as clay loams and clays, have high water-yielding properties. The amount of readily available water from 1 foot of depth is about $\frac{1}{2}$ inch depth from sandy soils and from 1 inch to 2 inches from loams and clays. For plants obtaining their water supply only from the first foot of soil, it is evident that replenishment must be made at frequent intervals, and that sandy soils will require more frequent applications than loam and clay soils.

Soil texture is also an important factor in the penetration of irrigation water. Coarse-textured soils are more permeable than fine-textured soils. While the amount of water necessary to wet a coarse-textured soil to a given depth is small, the great permeability of such a soil may render it exceedingly difficult to apply that small amount. Any excess penetrating below plant roots is waste water and has no effect on the frequency of application to that part of the soil occupied by roots. The lower permeability of the finer-textured soils facilitates the application of small amounts of water.

Strip, or Border, Checks.—Pasture layouts under the strip-check method of irrigation are similar to alfalfa layouts, but generally the strips are narrower and somewhat longer and with steeper grades. The flow of water delivered at the inlet end of the check may vary from 0.2 to 1.0 cubic foot per second, according to the area of strip to be covered. Delivery streams of 5 to 7 cubic feet per second from canal or pump are distributed to a number of strips at each setting of the water.

This method is best adapted to the finer-textured soils of low permeability. Such soils permit a fairly large area to be irrigated in one strip, and hence less earthwork and fewer ditches and structures are required than on more permeable soils.

Smooth, gently sloping lands are readily laid out for strip irrigation, but the method is also used on rolling lands where the length and width of strips will be determined by local topography. In lands with considerable side fall, the strips must be narrow in order to reduce the amount of top soil moved in leveling operations between the border levees.

Border levees between the strips have a base width of about 2 feet and a settled height of about 6 inches. Levees are small because their sole purpose is to guide the stream of water as it passes down the length of

the check. Such small levees will, in time, be covered with grasses and the whole area utilized, as may be seen in the cover-page photograph.

Strip checks require grade in one direction. This grade may or may not be uniform, but where possible it is desirable to have the steepest slope at the inlet end of the strip.

In constructing a strip-irrigation layout, the land should be plowed, depressions filled, and the whole smoothed with a float before constructing border levees. After constructing levees, the ground between them

TABLE 1
SIZES OF STRIP CHECKS FOR CLAY LOAM AND CLAY SOILS

Flow delivered to each strip		Length of check for various widths of strip			
		10 feet wide	15 feet wide	20 feet wide	25 feet wide
<i>cu. ft. per sec.</i>	<i>gals. per min.</i>	<i>feet</i>	<i>feet</i>	<i>feet</i>	<i>feet</i>
0.2.....	90.....	440	.....	.....	.....
0.3.....	135.....	660	440	.....	.....
0.4.....	180.....	880	.....	440	.....
0.5.....	225.....	.....	660	.....	440
0.6.....	270.....	1,320	880	660	.....
0.7.....	315.....	.....	.....	.....	.....
0.8.....	360.....	.....	.....	880	660
0.9.....	405.....	.....	1,320	.....	.....
1.0.....	450.....	.....	.....	.....	880
1.2.....	540.....	.....	.....	1,320	.....
1.5.....	675.....	.....	.....	.....	1,320

should be leveled transversely and the layout tested by running water over the land before planting. A number of ingenious power machines, which build borders and level the ground between them in one operation, have been constructed by land-leveling contractors. The usual width of strip constructed by these machines is about 13 feet.

The lower ends of the strips should be left open and provision made for the care of runoff water. Any ponding at the lower ends will destroy useful vegetation and result in the growth of water-loving types of plants.

Table 1, giving sizes of strip checks for clay loams and clays, will be found useful in planning a strip-check layout.

Strips longer than 800 feet with steep grades should be limited in width to 15 feet or less, and flow reduced somewhat from amounts given in the table. Grades of 0.2 to 0.5 feet per 100 feet are desirable for covering the ground quickly, but steeper grades are found in some sections.

For permeable loams and sandy loams, the delivery rates for the same sizes of checks as given in the table should be increased from two to five

times in order to cover the ground quickly and avoid excessive application at any single irrigation, or shorter checks may be used.

Structures required for delivery of water where checks are large and a high rate of delivery is necessary, include ordinary wooden field gates such as are used in alfalfa irrigation. For narrow and small checks, some form of slide gate which will give close regulation is required. These may be attached to tubes of suitable size passing through the ditch bank. Tubes may be wood, metal, or small concrete pipe. Metal or wood control slides operating in wood, metal, or concrete slots regulate the flow of water. Ordinary galvanized-iron control gates are sometimes badly bent

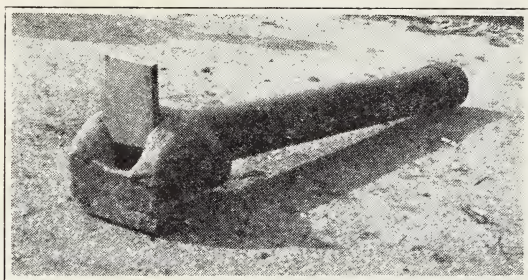


Fig. 5.—A concrete header for outlet pipe, formed in place.

by stock when used in exposed locations. Wooden slides appear to be more durable. A cheap and simple control device is shown in figure 5. This gate is constructed in place, without forms, digging out at the head of tube and filling space with concrete which is shaped by hand. The wooden slide is manipulated so as to form slots in the concrete. A rather dry mix which will not slump should be used.

Concrete pipe lines are most useful where topography is rough and where close control is necessary. Delivery valves are located at the head of the levee between two adjacent checks. The total number required is half the number of checks served. Water to each is controlled by so-called "orchard valves" usually of 4-inch size, and delivery to the two adjacent checks is through two furrow gates in the stand, which are regulated by small, galvanized-iron slides. Sizes of these gates will vary with the delivery required. Sizes observed in the field were 2, 3, and 4 inches in diameter.

More land preparation is required for strip checks than for any other type of flood irrigation. The preliminary work requires considerable surveying and planning to fit the layout to topography in order that the amount of earthwork shall be a minimum. A contour map, while not

absolutely necessary, will be very useful. Local contractors having specialized equipment do most of this work. The following itemized statement for 108 acres of flat land in Merced County⁵ will indicate costs of preparation up to seeding.

Item	Cost per acre
Preliminary work	\$ 4.25
Surveying	1.79
Removing covercrop	1.67
Plowing	4.43
Leveling	5.90
Checking (machine-made strips 13 feet wide)	3.00
Irrigation gates (not main ditch structures)	6.34
Service ditches and drains (not main ditches)	3.46
Supervision	1.68
Compensation insurance	0.50
	<hr/>
	\$33.02

Labor costs of irrigation by strip checks vary with the total number of irrigations, the size of stream to be distributed, and the length of time water is allowed to run at a single setting. Where water is furnished by an irrigation enterprise, delivery is usually on a 24-hour basis and provision must be made for night irrigation. With pump supplies, lands are usually irrigated only in daylight hours. With a large stream divided between a few strips of small area, such as would be required for sandy soils, water changes would be at frequent intervals and close attention would be required. Under such conditions the irrigator would have to devote his entire time to water deliveries. Where individual deliveries to strips are small and the checks are large, as for clay loams or clays, the water is allowed to run for a long time and the irrigator may not devote all his time to water deliveries.

Records of labor costs for strip-check irrigation on twenty-three Tulare County farms varied from \$1.20 to \$14.78 per acre per season, the average of the lowest twelve records being \$2.23 per acre, and of the highest eleven being \$9.70 per acre. The average of all records was \$5.27 per acre per season.

Contour Checks.—In the contour-check method of irrigation, the land to be irrigated is divided into a series of irregular basins by levees which follow lines of equal elevation. Contour levees are located by means of an engineer's level and rod and the vertical interval between the bases of successive levees is usually 0.2 foot. This method is adapted to flat

⁵ This estimate and the one for contour checks given later were furnished by the Crocker-Huffman Land & Cattle Co., Merced, California.

or gently sloping lands where large heads of water are available and where soils are of low permeability. Where lands are so flat that very large areas would be enclosed by levees located on 0.2-foot vertical interval, the basins may be divided by cross levees or the interval reduced. Lands are not leveled, other than filling depressions, between adjacent contour levees. Consequently, the depth of water over the basin, when filled, is not uniform, being deeper at the lower contour levee by the amount of the vertical interval. Irrigation is from basin to basin, water being drained from the upper to lower basins successively. Excess water from the last check is discharged to lower lands or to wasteways.

Large delivery heads, 6 to 10 cubic feet per second, are desirable for contour irrigation. Such heads will cover large areas adequately with a minimum of irrigation labor. Areas of 1 to 2 acres in each check are usual, but areas up to $4\frac{1}{2}$ or 5 acres have been successfully irrigated.

Since no general land leveling is done in constructing a contour layout, the required earthwork consists of building levees and field ditches. Contour levees are about 4 feet broad at the base and from 15 to 18 inches high when first constructed. The principal structures are ordinary stop gates. Where cattle and horses are pastured, structures should be especially well built in order to withstand trampling. The following costs for 2,176 acres in Merced County are representative:

Item	Cost per acre
Preliminary work	\$ 0.44
Surveying	0.33
Removal of covercrop	1.11
Plowing	3.82
Leveling (smoothing)	1.85
Checking (levees)	2.76
Irrigation gates (not main ditch structures)	5.08
Service ditches and drains (not main ditches)	1.00
Supervision	1.24
Compensation insurance	0.23
	<hr/>
	\$17.86

Labor costs for irrigation by contour checks are lower than for any other system of flood irrigation. On the large area shown in this tabulation, four irrigators working 12 hours a day handled the entire area at a cost of \$1.46 per acre per season. The average cost of labor for nine Merced County farms totaling 3,438 acres was \$1.76 per acre per season.

Wild Flooding.—The common method of irrigating pastures in the Sierra Nevada foothills is by spilling from ditches located on ridges

or on flat grades across the steepest slope. Delivery heads are small, from $\frac{1}{2}$ to 1 cubic foot per second. No earthwork is done except to plow out distributing ditches, which are located on grades of $1\frac{1}{2}$ to 2 inches per hundred feet. The few structures used are of simple design and easily constructed.

The amount of labor involved in using this method is greater than for the two methods previously described. Practically continuous attention is required by the irrigator while the water is running. Water is raised in the distributing ditch by building a dirt dam at the downstream edge of a section to be irrigated, and the ditch bank is then opened at a number of places above the temporary stop. When the first section is watered, the operations are repeated for other sections along the ditch. An irrigator can water about 4 acres per day by this method.

Sprinkling.—Sprinkling is one of the newer methods of irrigating pastures. The uniformity of coverage and the possibility of controlling the amounts of water applied at each irrigation are factors favoring the use of this method for sections of high water cost, for pastures located on coarse-textured, permeable soil, and for locations difficult or impossible to level.

Sprinkler systems are of three general types: (1) those having underground main and lateral lines with rotating sprinklers in fixed locations; (2) those with underground or portable main lines with portable lateral lines equipped with rotating sprinklers; (3) those with portable surface pipe main lines with the end sections perforated for spray irrigation.

Systems with underground main and lateral lines require large investment per acre. In order to reduce pipe costs, the spacing of the lateral lines and of the sprinklers should be as great as is consistent with operating pressures and reasonable uniformity of distribution. With wide spacing, operation pressures must be high. The usual operating pressures are from 40 to 50 pounds per square inch at the pump. While first cost and power charges are high for sprinkler systems in fixed locations, the labor charges for such systems are very low.

Systems with fixed main lines with portable laterals are lower in first cost than those described above. Operating pressures are the same, but labor charges for moving the lateral lines add considerable to the cost of operation. Time out for moving lines reduces the percentage of total time which the sprinklers can be operated. In irrigating other crops, studies showed that twenty-five systems using two distributing lines operated 85 per cent of the time, while thirteen single-line systems operated only 67 per cent of total irrigation time.

Similar systems showed power and labor costs per acre-inch of water applied as follows :

System	Power	Labor	Total
22 systems, double lines.....	\$0.20	\$0.51	\$0.71
17 systems, single lines.....	\$0.26	\$0.72	\$0.98

Perforated-pipe systems are cheaper in first cost than either of the other systems and will operate on pressures as low as 8 to 10 pounds per square inch. A strip from 30 to 35 feet wide and as long as the perforated section of the pipe is wetted at each setting. Rates of application by this method are high, the lowest rate being about 1 inch in depth per hour for the area covered. For an application of 2 inches in depth the line would have to be moved every 2 hours. Power costs are low for this system, but labor charges are high.

In general, sprinkling is limited by its high cost to small areas which cannot be irrigated by other methods.

Computation of Amounts of Water Applied.—As a means of checking up on irrigation practices, the depth of water applied to any field in a given time by a given flow may be easily computed by using the following approximate formulas :

$$1. \frac{\text{Flow in cubic feet per second} \times \text{hours run}}{\text{Number of acres irrigated}} = \text{inches depth applied}$$

or

$$2. \frac{\text{Flow in gallons per minute} \times \text{hours run}}{450 \times \text{number of acres irrigated}} = \text{inches depth applied}$$

Example 1, using formula 1

Area, 40 acres

Flow, 8 cubic feet per second

Time to irrigate, 15 hours

$$\frac{8 \times 15}{40} = \frac{120}{40} = 3 \text{ inches deep}$$

Example 2, using formula 2

Area, 25 acres

Flow, 900 gallons per minute

Time to irrigate, 40 hours

$$\frac{900 \times 40}{450 \times 25} = \frac{2 \times 8}{5} = 3.2 \text{ inches deep}$$

By performing similar calculations, the irrigator is in a position to determine the efficiency of any particular layout. Such calculations may indicate needed changes in operation or layout.

Use of Water.—The total amount of water used will depend on temperature, length of growing season, frequency of application, depth of wetting, and to some extent on plant types and irrigation method and layout. In northern counties the short growing season limits total use, while in coastal regions the lower temperatures reduce transpiration rates. The high summer temperatures and long growing season of the interior valleys are reflected in greater use of water.

Water applied at each irrigation is always in excess of the transpiration uses of the plants, and under some conditions this excess is considerable. Each time the pasture is irrigated, a portion of the water applied is lost by surface evaporation. If the soil type necessitates frequent applications, the proportion of water lost by surface evaporation is increased. The amount of water applied and the soil texture determine the depth of wetting. Coarse texture tends to increase water application at a single irrigation and for the season. The difficulty of wetting soils uniformly to the depth of the roots results in the application of excess water. In some cases runoff water is discharged to wasteways.

On coarse-textured soils in the interior valleys, it is often necessary to irrigate every week. Observations show that the number of irrigations during the season may range from 15 to more than 20 with a total use of 6 to 10 acre-feet. On deep permeable loams and silt loams at the University Farm at Davis, irrigations were at 10-day intervals and the water use for the season was 5 to 6 acre-feet. Actual measurements of water on pastures on shallow clay loams in the Sierra foothills of Nevada County showed a total annual use of $2\frac{3}{4}$ to 3 acre-feet applied in 12 irrigations. The length of the irrigation season was 6 months. On heavy Madera clays in Merced County, approximately 3 acre-feet of water was used during the season, the applications being at 12-day intervals.

While it is difficult to estimate beforehand the total water use of pasture crops and the frequency of application, it would appear that a total use of 5 acre-feet applied in 15 irrigations is a satisfactory basis for planning the enterprise.

Cost of Water.—The principal cash costs of irrigated pastures are for water and for irrigation labor. The latter costs are discussed under the various methods of irrigation.

The sources of water are by irrigation enterprises and private pumping. The various enterprises usually deliver gravity water and the cost varies considerably. While in some sections the cost may be less than \$2 per acre per year, the annual charge for the majority varies from \$3 to \$5, with higher costs of \$8 to \$10 in other areas. Under most of the

gravity systems, water costs are on an acreage basis and water is not measured carefully. Certain systems may not be able to furnish late-season water, in which case, resort must be had to private pumping.

The cost of pumping varies with the type of power used, the total pumping head, over-all efficiency, and total use of the plant. The costs indicated below are for electric power alone, the overhead being considered as part of the general overhead expenses of the farm enterprise.

With an over-all plant efficiency of 60 per cent, an estimated use of 5 acre-feet per acre per season, and a pumping capacity of 1 cubic foot per second for 40 or more acres, power costs, under commercial rates, will

TABLE 2
COST OF ELECTRIC POWER

Lift from well	Lift above ground and pipe friction	Total pumping head	Use per acre per year	Acre-feet × pumping head	Power costs per acre
<i>ft.</i>	<i>ft.</i>	<i>ft.</i>	<i>A.-ft.</i>	<i>A.-ft.-ft.</i>	<i>dols.</i>
60	0	60	3	180	3.60
60	30	90	3	270	5.40
60	0	60	5	300	6.00
60	30	90	5	450	9.00
60	0	60	7	420	8.40
60	30	90	7	630	12.60

approximate 2 cents per acre-foot per foot of lift. If overhead costs on pumping are considered separately, an additional allowance of 1 cent per acre-foot per foot of lift should be made. Table 2 shows the cost of electric power for various pumping heads and various amounts of water.

An average cost of water of \$8 per acre per year is a fair figure for use in planning an irrigated-pasture enterprise.

SEEDBED PREPARATION AND SEEDING

A seedbed that is satisfactory for seeding alfalfa should be adequate for an irrigated pasture. This means that there should be a firm bottom so that the small seeds can come in close contact with a firm wet soil, with a very light covering—not over $\frac{1}{2}$ inch in most soils. Preirrigation performs several important functions: (1) it settles the grade and discovers potholes and other irregularities that can be corrected before seeding; (2) it firms the soil for seeding; (3) it provides an even and dependable moisture supply for germinating the seed. It is not always essential if there has been enough rainfall just before seeding.

Seed of known identity, purity, and viability should always be used. Irrigated pastures are primarily a long-time crop, and it is important

to know that all of the constituents have a maximum opportunity to survive and grow. Weeds from other sources are a constant menace in any event. No careful operator will knowingly plant them to increase their hazard. Certified seed, labeled as to purity, germination, and contamination, is the only safe guide in planting seeds. This is especially true of Ladino clover, which may contain seed of common white Dutch clover, plantain, or other undesirable species, unless this has been guarded against in the process of certification.

Seeding may be done by broadcasting or drilling. If drilling machinery for small seeds is available, this will probably do the best job; but if it is not, broadcasting and covering by a light harrowing is very satisfactory. Methods of planting vary widely in different parts of the state and among individual producers. Some plant the grass and clover seeds separately, others mix and sow them all at once. The theory that clover seeds settle to the bottom in a mixture is not generally borne out in practice when the seeding is done by hand. If a broadcast seeder or drill is used, then the grass and clover seeds should be planted separately since they will not feed evenly through the ordinary seeding equipment. Some make two sowings of all species at right angles to each other for more even distribution. Any method that will give an even distribution of all species is satisfactory.

Time of seeding does not vary greatly in the county recommendations that are available. In Shasta County, October 1 to November 15 seeding is recommended; in Riverside County, October, November, or February; in Madera County, December to February; and in Orange County, early December or early March. All of the varieties commonly used in an irrigated-pasture mixture will germinate and grow in the fall, except Dallis grass and Rhodes grass, and these will usually remain dormant for a spring germination to a sufficient stand. Fall and winter temperatures and moisture conditions are generally more favorable for continuous and adequate soil moisture until the young plants are so well established that irrigation can be applied without danger of washing; surface crusting is also less likely to occur in soils that have that tendency when drying. Winter temperatures, however, are likely to be fatal to sprouting plants in the northern and colder parts of the state. Summer heat is not conducive to the best results in any part of the state. first year after seeding. Most of the perennial grasses used do not develop

PASTURE MANAGEMENT

It will not generally be possible for a grazier to determine the full success of his seeding or the average composition of his stand during the

fully until the second or third year. Some of the seeds may lie dormant for a considerable time awaiting favorable soil temperature or moisture conditions. Ladino clover usually contains a rather high percentage of hard seeds, which will not germinate until the seed coat has been softened by long contact with moisture. Many seedlings that have appeared as virtual failures the first year have developed into satisfactory stands and good mixtures.

One of the reasons for using ryegrasses is that they germinate and grow rapidly and provide much of the forage during the first pasture season. When the ryegrass is 6 to 8 inches high, the field may be pastured without injury to it or to other species, if the stock are on it only while actually grazing, if it is not pastured too close, and if no stock are on the field while the soil is wet.

The three chief objectives of a pasture operator should be (1) to maintain an adequate stand and balance of legumes and grasses through as much as possible of the pasture season, (2) to obtain and perpetuate the highest possible carrying capacity, and (3) to utilize the feeds at their highest possible nutritive value. The proper use of irrigation water (on land that has been well prepared for its even and adequate distribution) and the proper management (or rotation) of livestock contribute more to these objectives than any other items. Irrigation facilities, layouts, and practices are discussed in an earlier section (p. 14). Since water is generally the most expensive single item, its proper use without waste is doubly important in economic pasture practices.

Obtaining the Best Feed Value from a Pasture.—The following tabulation shows the variation in the protein content of some plants at different stages of maturity :

Plant and stage	Digestible protein, on the basis of 15 per cent moisture
Alfalfa:	
Immature	17.0
After bloom	5.4
Kentucky bluegrass:	
Before heading	15.0
After bloom	2.7
Orchard grass:	
Before heading	13.0
After heading	4.9
Sudan grass:	
Before bloom	5.9
In seed	1.8

Plant and stage	Digestible protein, on the basis of 15 per cent moisture
Timothy:	
Pasture stage	13.9
In seed	2.2
Mixed grasses:	
Immature	10.3
At haying stage	4.7
Mixed grasses and clover (closely pastured)	13.0

Obviously, animals on a good pasture of immature grasses and clover receive a liberal supply of protein, which is usually the most costly element in a livestock ration. The protein content declines when pasture plants flower and ripen. Both of these factors should be taken into account when a concentrate is added for livestock on pasture to promote fattening or to increase milk production.

After toughening of grasses begins, which happens at about the flowering stage, the crude fiber of pasturage increases in percentage, becomes difficult to digest, and hinders the digestion of its other nutrients. The average digestibility of the dry matter of immature grasses is about 71 per cent, whereas that of hay from the same plants at a more mature stage is only about 59 per cent.

Immature pasturage gives animals a better supply of vitamins than is practical by any other method. It is especially rich in carotene, from which vitamin A is made in the animal body. With dairy stock, this results in a higher vitamin-A content in the milk.

Green, immature plants are much better sources of minerals than hay or mature plants from the same land. Immature grass is usually about twice as rich in phosphates as mature freshly cured grass.

Livestock will thus derive the greatest nutritive value from plants before the seeds have matured. On the other hand, plants cannot survive in full vigor unless they are allowed to mature sufficiently to nourish themselves. There is no accurate rule that can be applied to all species in a pasture simultaneously, by which the best feed value can be obtained without injury to any of the plants. In general, when a plant begins to flower, it will have nourished itself sufficiently so that its top may be grazed or clipped without injury.

Livestock Rotation.—Rotation of grazing livestock must in general be timed to fit in with irrigations. Grazing of an area must be deferred until the soil has dried to a point where the plants will not be injured by trampling or impaction. Enough subdivisions, or paddocks, should

be provided so that a rapid cleanup can be accomplished during the spring when plant growth is flushest. During the months when growth is less rapid, two or more paddocks may be utilized at the same time (fig. 6).

Many of the objections to certain grasses have arisen through faulty management in grazing them. Dallis grass, as an example, while it starts rather late in the spring, is a rapid and persistent grower throughout the summer and develops its seed heads in rather short intervals after grazing. After it has once formed seeds, the stock avoid it, and thus we find



Fig. 6.—An irrigated pasture with enough paddocks to provide an adequate year-round grazing rotation.

in some pastures many matured plants of Dallis, while the other species have been grazed more closely and uniformly (fig. 7). In fields where Dallis (or any other species) predominates at some time during the season, the rotation should be so planned as to crop it when it is most nutritious and palatable. In some pastures orchard grass is not looked upon favorably because it tends to form coarse tufts or tussocks. A proper association of any of these bunch grasses with Ladino clover can only be accomplished by a rotation calculated to prevent them from reaching an advanced stage of maturity. And any rotation that is adequate must be so flexible that it can be adjusted to meet the growth habits of all the plants in the mixture.

In general, rather close and prolonged cropping tends to increase the clovers at the expense of grasses. Conversely, infrequent and insufficient grazing tends to produce a predominance of grasses over clover. A good rule-of-thumb which seems to be reasonably satisfactory is to put live-

stock on a pasture when the Ladino clover begins to show considerable bloom. But no definite rule can be given to cover all pasture plants, all sites, and all seasons. Maximum feed values and carrying capacity will usually be obtained when enough animals are turned in to crop the growth moderately close and evenly in a rather short interval (3 to 6 days). Where high-producing dairy cows are concerned, it may be advisable to give the latter part of each rotation over to young or dry cows.

Consideration of the following facts may serve to emphasize the need for adequate pasture management throughout the growing season. If the soil, climatic, and moisture conditions are favorable, the competitive



Fig. 7.—Grasses too mature, with much feed value and grazing capacity lost. Clipping and closer grazing in smaller paddocks will aid in correcting this condition.

ability of any plant in the mixture will depend on its height and density when allowed to mature. Measured by these criteria, orchard grass is more aggressive than Domestic ryegrass, much more than perennial ryegrass and Ladino clover. The same factors exert a marked influence on the seasonal succession of species. If the early species are allowed to grow to full maturity, or even full height, they tend to weaken and suppress the species that normally come on later. From this it becomes evident that proper pasture management depends upon subduing, by grazing or clipping, the more aggressive species at the time their growth is strongest in order to maintain a good mixture and a long pasture season. Management then must seek to level off as much as possible the difference in growth habits of the various species we must use to have a good pasture mixture. Generally speaking, such management will serve to utilize these plants when they are most palatable and nutritious. Plants with stolons or rootstocks, such as Kentucky bluegrass and Bermuda grass, are probably exceptions in that their creeping habits enable them to create a

considerable colony of sod which resists the encroachment of other species.

Clipping.—If the livestock numbers on any given farm are properly balanced with year-round feed supplies, there will probably be an excess of pasture during the spring months of flushest growth. At this time hay supplies may be considerably augmented by so adjusting the rotation that each paddock may be clipped at least once. This practice has other benefits. It is one means of controlling the growth of weedy plants and of reducing the coarse growth that has accumulated around cattle drop-



Fig. 8.—Coarse, ungrazed clumps around cattle droppings. These can be reduced by clipping and harrowing.

pings (fig. 8). Even in fields that are being pastured, occasional clipping is a beneficial practice in reducing weeds and promoting even cropping and full utilization.

Harrowing.—Harrowing of pasture to spread the droppings of cattle has long been a regular practice in most foreign countries. A New Zealand authority has calculated that the droppings of a herd of 30 cows, if fully utilized, have the following annual fertilizer values: 9 tons of sulfate of ammonia, $2\frac{1}{4}$ tons of superphosphate, $4\frac{1}{2}$ tons of potassium. On the other hand, unscattered droppings of 30 cows would mean a loss in potential grazing areas in and around the droppings equal to $4\frac{1}{2}$ acres a year. Four types of harrows now in use for breaking up and spreading cattle droppings are shown in figure 9.

Fertilizing.—It is too frequently assumed that pasturing livestock return enough manurial material to the soil to maintain maximum yields.

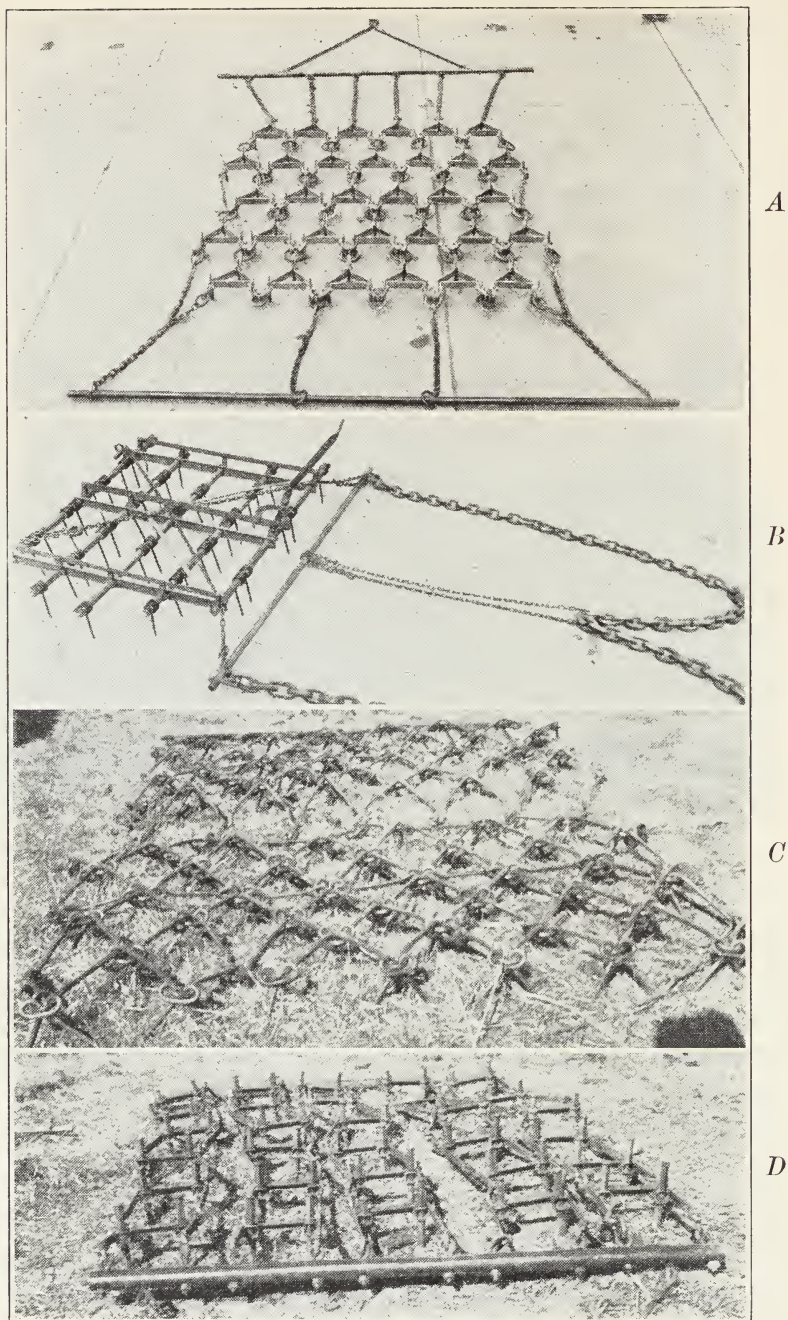


Fig. 9.—Types of harrows used to spread cattle droppings: *A*, a Swiss type used at Tillamook, Oregon; *B*, a Weiss coil-spring harrow; *C*, an English link harrow; *D*, a flexible peg-toothed harrow built by the Division of Agricultural Engineering of the University of California.

This is not true. Much of the soil fertility is converted into milk, meat, or wool, and thus is permanently removed.

It must be remembered that Ladino clover and some of the grasses that are used with it are shallow-rooted. A high percentage of the plant foods that support them are taken from the first foot of soil. Their drain upon soil resources is therefore heavy. It is reasonable to assume, then, that the legume or the grasses, or both, may eventually show signs of decreased vigor. In some California soils, this has not become evident in fifteen or more years of pasture use. In others it may occur in a much shorter interval, while in still others maximum production can never be attained without adding one or more fertilizer elements to the soil.

Need of fertilizer can best be determined by plot tests on each site, and such tests should always be made in any system of adequate pasture management. Fertilizer practices should then be based on the results secured from plot tests to determine plant responses.

On some soils no profitable response has been secured from any known element of plant food. This may simply mean that the soil is capable of supplying plant needs without additional supplies. There are a few cases, however, when this is true where the level of production is below a profitable grazing capacity, and in such instances it may mean that the sites are not adapted to irrigated-pasture production.

Nitrogen, phosphorus, potassium, lime, sulfur, or some micronutrient element (an element necessary to plant growth but in minute amounts) may be deficient when production is not adequate or begins at some time in the life of the stand to decline. It is in the determination of these facts that plot tests are useful. On many soils, legumes respond to phosphorus and grasses to nitrogen (fig. 10).

In addition to maintaining general production, fertilization may be a valuable aid in maintaining the balance of legumes and grasses. Thus if the legume is deficient it may possibly be stimulated by the addition of phosphorus (or sulfur or some other element to which it has shown a response). If the grasses are low, they can almost invariably be stimulated by the addition of nitrogen. No legume or grass can, of course, be stimulated by fertilizer applications into growth during the season when it is naturally dormant.

There is perhaps no fixed time to apply fertilizers. Usually applications in the spring (January to March) seem to produce the best results. In the older pasture districts, it has generally been found that annual top-dressings in amounts determined to be adequate for plant needs for the season are preferable to larger amounts applied at two- to five-year intervals.

Control of Weeds.—Besides the weedy species discussed above, there are many other and less palatable species that are encroaching on irrigated pastures to such an extent as to greatly reduce the carrying capacity. No successful grazier can afford to neglect this menace. Primary control measures begin with the seed used in planting. This should be free of weed contamination. Despite the most careful management, however, weeds will be likely to encroach upon pasture areas.

The occurrence of certain sedges and swamp grasses is usually an indication of faulty land preparation and irrigation practice, since these



Fig. 10.—Typical responses to fertilizers: foreground, pasture fertilized with phosphate, which stimulates clover; right background, pasture fertilized with nitrogen, which stimulates grasses.

species thrive in lands too wet for ideal pasture plant responses. Such plants as dock (*Rumex* spp.) should be promptly attacked on their initial appearance and removed by pulling or grubbing before the seed heads mature. Persistence is essential, but this is doubtless the cheapest and most effective method if done in time. Various species of plantain may also become obnoxious. Sheep will keep most of these in check, but they are not relished by cattle.

Occasional clipping for weed control has been previously mentioned and is an effective method of reducing their growth and spread.

ADDING MIXTURES TO ESTABLISHED STANDS

Legumes in Bermuda-Grass Stands.—Many producers who have dense resident stands of Bermuda grass have been interested in some legume as an associate with it to enrich the feed and increase the carrying capacity.

In a number of counties, methods of accomplishing this with Ladino clover have been worked out very satisfactorily. In most cases the stand of Bermuda has been reduced to a satisfactory ratio and in a few instances Bermuda has been practically eliminated, but this should not generally be anticipated.

In seeding Ladino clover in Bermuda grass, advantage should be taken of the fact that this grass is a summer grower and dormant in late fall and winter. Bermuda sod should be disked thoroughly in the fall and reduced to as good a seedbed as possible for the sowing of clover. The Ladino will start in the fall and will usually be ready to compete with the Bermuda by the time the latter becomes active in the spring. Bermuda grass will endure more drought than Ladino clover, so it is essential to have ample water supplies and to irrigate frequently, especially on the light soils where Bermuda is most likely to thrive, if a satisfactory association is to be achieved. Success is also more likely to follow where the irrigation slope is nearly flat than where there is a considerable grade. It has frequently been demonstrated that 150 to 200 pounds of superphosphate per acre applied annually will stimulate the clover and thus aid in crowding out the grass.

Bermuda frequently thrives in land that is too alkaline for the best growth of Ladino. In such areas bird's-foot trefoil (*Lotus corniculatus*) has been found to be a good legume to compete with it. This is especially true in seepage areas adjacent to canals or ditches where the lotus can secure underground moisture supplies. The methods of seeding and management are similar to those given above for Ladino clover and grass mixtures.

Ladino Clover in Johnson-Grass Stands.—Numerous tests in many parts of the state have shown that Ladino clover will also associate with Johnson grass. Since the growing season of Johnson grass is similar to that of Bermuda, the seeding practice should be similar. After that, irrigation and management become the deciding factors. Livestock will consume liberal amounts of Johnson grass in combination with clover as a natural method of balancing their own ration. But since Johnson is a tall-growing grass, it may soon become too tall and coarse to be relished and will then begin to exert a deterrent effect on the clover by crowding and shading. Mowing should then be applied to reduce the grass competition and promote new and more palatable growth. Johnson grass will be greatly weakened and may eventually be eliminated if the top growth is thus kept down, since this kind of management gradually saps the coarse tuberous roots essential to the nourishment of the tops.

LEGUME AND GRASS SPECIES USED IN IRRIGATED PASTURES

The species that are recommended for general-purpose and *special* mixtures in the various counties are shown in the section on mixtures. It may serve some useful purpose, however, to discuss the growth habits, special uses, and limitations of these species briefly here.

It has been said that most bunch grasses are too coarse and tufty to make an ideal mixture with Ladino clover. A sod-forming or colony grass, with rhizomes, or rootstocks, such as Kentucky bluegrass in its optimum habitat, would seem to be better suited to an ideal association with most legumes. No such grasses are now available that are generally adapted to California conditions. In the present status of the matter, it is well to remember that where irrigation water must be applied at frequent intervals and where other operating and overhead costs are as high as those a producer must meet in this state, high production in terms of carrying capacity is the most vital consideration. In meeting this requirement, the bunch grasses have no equal among those that are now available. Pasture operators should therefore select those of good feed value that will yield the most pasturage and then adjust management to make the best possible use of them.

Ladino Clover.—A perennial and a native of Italy, Ladino clover (*Trifolium repens* var. *latum*) is presumed to be a large form of white Dutch clover. Top and root length varies from 6 inches to over 2 feet, according to the depth, porosity, and fertility of the soil. The true stems are prostrate, remaining close to the ground, and are rather coarse, with short joints or internodes. In favorable moisture these stems will elongate and take root at the nodes, so that even a sparse stand will soon thicken and produce a dense growth. Unlike Dutch clover, however, Ladino does not often establish new independent plants by this vegetative process. The popularity of this plant for pastures rests mainly upon its ability to recover rapidly from grazing or clipping and the further fact that most of its growth is leafy and succulent rather than stemmy. A complete recovery after grazing often takes place in 2 weeks so that it is an able competitor with most grasses. Its growing season is as long as that of any other available legume, though it does become winter-dormant in practically all parts of the state. The length of this dormancy depends upon the severity of the winters. In the warmer parts of the main valleys, it is also subject to a slight midsummer growth sag.

Alfalfa.—Alfalfa (*Medicago sativa*) requires no description. The common, or Chilean, alfalfa is generally used, though Baltic, Grimm, or

Ladak are sometimes seeded in areas with severe winters. The chief use of alfalfa is on soils too porous or otherwise not adapted to Ladino clover, or where irrigation cannot be given often enough for the latter. Alfalfa is sometimes used along with Ladino, to maintain the legume content of the pasture during the hottest months or to seed the borders or strips when it is necessary to make them so high that Ladino does not do well on them because of moisture deficiency.

Alsike Clover.—A perennial and a native of Scandinavia, alsike clover (*Trifolium hybridum*) has a place in irrigated pastures chiefly in the northern end of the state (Lassen, Modoc, Siskiyou, and eastern Shasta counties). On some sites farther south (notably the northern Sacramento Valley), it is incorporated in the mixture for heavy soils and sites where seepage or irrigation water concentrate to such an extent as to be intolerable for Ladino clover. It is primarily adapted to wet, cold, and sour soils of heavy texture.

Bur Clover.—An annual and a native of the Mediterranean region. Bur clover (*Medicago hispida*) has long been a common and valued inhabitant of all but the colder portions of California. It does not need to be seeded except in those fields where the natural stands have been eliminated or greatly reduced by close pasturing or previous farming practices. Being a winter annual, it is dependent entirely upon seed for reproduction. North of San Francisco it is not popular in irrigated pastures because it is there semidormant in the winter and starts in the spring very little earlier than Ladino clover. In the southern part of the state, however, it grows well all winter and thus fills the need for a legume to extend the pasture season.

Subterranean Clover.—An annual, subterranean clover (*Trifolium subterraneum*) is a native of Europe, Asia, and Africa. The climatic tolerances of this legume are similar to those of bur clover. It is a prostrate, soft woolly plant, all parts of which are covered with fairly long, soft hair. The three leaflets forming each leaf are carried on a long stalk and each leaflet is heart-shaped and faintly toothed at the summit. After flowering, the stalks which carry the flower heads turn downward and grow until the seed head is pushed below the surface of the soil. Although an annual, this habit of burying its own seed renders this plant equivalent to a perennial. Its season of growth is similar to that of bur clover and its place in the pasture would therefore be similar. Perhaps its chief advantage is that it will do well in really acid soils if there is sufficient available phosphorus. The general use of this clover is not now recommended. It is mentioned here chiefly because it has come into prominence recently and has already been found adapted to a considerable part of

the state. A few test plantings of it in districts where bur clover is recommended, or in some acid or granite soils where bur clover does not thrive, might well be made in order to develop facts as to its real place in irrigated pasture practice.

Strawberry Clover.—A perennial and a native of eastern Mediterranean countries and southern Asia Minor, strawberry clover (*Trifolium fragiferum*) is a low-growing plant that spreads by creeping stems that root at the nodes. The flower heads are round and pinkish to white in color, resembling an immature strawberry. This clover seems to have found a place in some northern areas of the state (particularly in the Tule Lake basin and on the coastal plains of Humboldt County). Its chief use elsewhere is on soils that are too saline to produce Ladino. While with ample irrigation, it has survived on such sites in the Sacramento and San Joaquin valleys, it has not yet become conspicuous in any of the warmer sections of the state as a producer of forage. There it is at best a low undercover plant that produces some feed and probably contributes some nitrogen to improve soil conditions. Further experience is necessary to define its range and usefulness in irrigated pastures in this state.

Bird's-Foot Trefoil.—A perennial and a native of Europe and Asia, bird's-foot trefoil (*Lotus corniculatus*) has recently been widely publicized and perhaps overstressed as a wonder forage for irrigated, semi-irrigated, and subirrigated lands. It is being widely tested throughout the state to find its best use and value, but as yet our experience with it is too limited to justify its general use in irrigated pastures. It is producing hay and forage on the coastal plains of Humboldt County and is being grown in the delta of San Joaquin and Solano counties and on a subirrigated field near Dos Palos in Merced County. These limited experiences, plus the early results of tests in a number of counties, indicate that this legume may have a place on moderately alkaline lands where irrigation or seepage waters are sufficient to meet its needs. The possible use of bird's-foot trefoil in dense Bermuda stands has been suggested elsewhere in this circular. It may well find a place in areas where irrigation water cannot be applied often enough for Ladino clover, but probably will not supplant the latter for general use.

Domestic Ryegrass.—Domestic ryegrass (*Lolium multiflorum*) is a short-lived perennial and a native of Europe. So much breeding and selection work has been done on the ryegrasses (of the genus *Lolium*) and so many local and trade names have thus been attached to them that a word of general explanation may not be out of place here. Practically all the cultivated ryegrasses originate in two species: *Lolium*

multiflorum, most commonly called "Italian ryegrass" or "annual ryegrass," and *L. perenne*, generally known as "perennial ryegrass," or "English ryegrass." Some call them both short-lived perennials, while others call Italian ryegrass a short-lived grass, usually an annual. Various selections of Italian ryegrass are known as "Western-grown," "Oregon grown," "Domestic," "Wimmera," and "Westerwold." Commercial seed now marketed here is most commonly known as Western grown or as Domestic ryegrass, and it seems fairly certain that this contains a considerable percentage of hybrids with perennial ryegrass. In any event, mother stools have been known to survive in California for three or four years. Pacey's ryegrass, Clunes ryegrass, and many other selections of perennial ryegrass have no outstanding merit above that of the parent. All strains of Italian ryegrass can be distinguished from perennial ryegrass by the fact that the emerging leaves are rolled while in the latter they are folded. Generally there are short awns on the seeds of Italian ryegrass and not on perennial, but this character varies markedly.

Domestic ryegrass is a more stemmy and less leafy plant than perennial. It owes its popularity as an irrigated pasture plant in California to its high palatability, its excellent growth and consequent high production and its early-spring growing habit. This latter quality renders it valuable as early feed and as a moderately good competitor with the flush spring growth of Ladino clover—hence a valuable bloat deterrent. No other grass we now have can compete with it in these respects. It does tend to become dormant in late summer and should be mixed with other grasses to supplant it at that season.

Perennial Ryegrass.—Perennial, or English, ryegrass (*Lolium perenne*) is fully as palatable as Domestic and bears more basal leafage, but does not produce as high a yield. It grows later in the summer and is desirable from that standpoint. In pastures that are to be used largely for sheep, this is probably a better grass than its coarser relative. Perennial ryegrass is no longer used in some areas of the state (notably the central coast) because of rust injury. It is to be hoped that a rust-resistant strain may eventually become available.

Orchard Grass.—A perennial and a native of Europe, orchard grass (*Dactylis glomerata*) can be readily distinguished by its large circular bunches, folded leaf blades, and compressed or flattened sheaths (especially at the base of the stems). The shape of the flower head has suggested the English name of "cocksfoot." Though orchard grass is coarse and tufty, it has retained its popularity in pasture mixtures here because it is hardy, persistent, and aggressive and is relished in the earlier stages

of growth by all classes of livestock. Even sheep relish the abundant leafage, though they are inclined to avoid the main culms and heads. Thus they often permit too much maturity and woodiness, and coarse tussocky bunches result, which lead to some complaint against this valuable grass. Careful management is essential, and clipping should be resorted to whenever necessary to keep orchard grass from getting beyond the stage of greatest usefulness.

Meadow Fescue.—A perennial and a native of Europe, meadow fescue (*Festuca elatior*) is a tall-growing bunch grass that normally ripens as a midseason grass. But it is very favorably considered in the Middle West as a late fall feed, since it remains active very late under grazing. It is not so tufty as orchard grass, but contains much basal leafage which is bright green and very succulent. Meadow fescue starts very slowly in a mixed pasture and may not be much in evidence for several years. Under proper management it should be very durable, particularly where summer temperatures are not too high.

Tall Fescue.—Tall fescue (*Festuca elatior* 29366) is a selection of meadow fescue and, like it, a perennial, but more drought-tolerant. It is thriftier in growth than the parent and bears more abundant basal leafage. Tests of two years here in California have indicated that it is adapted to a wide range of conditions.

Harding Grass.—A perennial, Harding grass (*Phalaris tuberosa* var. *stenoptera*) came to us from Africa though the species, *P. tuberosa*, is a native of the Mediterranean. Harding grass grows in large, dense, leafy tufts. When once established, it is very persistent. High seed prices and low germination have hindered the fullest use of this plant. It is one of the few perennials that makes a good growth during the winter when most other plants are dormant, but it will not survive the cold winters of northeastern California. Harding prefers heavy black soils and deep volcanic loams, but will produce well on lighter soils underlain by heavier strata. Though a tall and rather coarse grass, its abundant leafage is relished by all classes of livestock. Only a light seeding (2 to 3 pounds per acre) is recommended as a means of prolonging the pasture season in the more temperate parts of the state.

Dallis Grass.—A perennial and a native of South America, Dallis grass (*Paspalum dilatatum*) normally has a deep, strong root system and grows in clumps which tend to die out in the center and enlarge around the periphery as the plant ages. Ladino-clover plants in association with it are often found occupying the centers of these old stools. After nearly twenty years of experience, this association is classed as ideal by graziers who like Dallis grass. The leaves are numerous near

the ground but few on the stems, which are usually drooping or angled. In most of the state (except the colder portions where it will not survive the winters), it starts rather late in the spring and becomes dormant in the fall. But during the summer its recovery after grazing is more rapid than that of any other grass we have. Its aggressiveness in this respect has brought it into disrepute with some operators since, like other grasses, it is not so palatable as it approaches maturity. Some irrigation districts oppose the use of this grass because its light oily seeds float on the water and the plants become established along the ditch banks. The contention does not seem well founded since such areas are generally occupied by plants much less desirable, and frequently more difficult to control than is Dallis grass.

Smooth Brome.—A perennial and a native of central Europe and China. Smooth brome (*Bromus inermis*) is a tall-growing leafy grass that spreads by underground creeping rhizomes which tend to become sod-bound in a few years so that renovation is essential to the best results. In northeastern California, smooth brome is popular as a hay and pasture plant, but it has never found a place in any part of the state where the winters are mild and summer temperatures high. Its general use is therefore not recommended.

Kentucky Bluegrass.—A perennial and a native of Europe and Asia, Kentucky bluegrass (*Poa pratensis*) is a true creeping, or colony, grass. While it is primarily adapted to the colder parts of the state, it is not generally recommended there for planting in a pasture mixture. The objections to it are that it produces too dense a sod and that its growth is not luxuriant enough to provide adequate livestock-carrying capacity. In recent years Kentucky bluegrass has come into the pasture picture in parts of the San Joaquin and Sacramento valleys. Some producers believe it has a place there in association with Ladino clover, especially for sheep. Observations in several counties indicate that it is crowding out the clover and that it does not yield so much forage as the stronger-growing plants available. This may be partly due to a lack of adaptation in these areas. Prospective planters should make observations on local experience, where available, before committing themselves to bluegrass in irrigated pastures.

Rhodes Grass.—A perennial and a native of South Africa, Rhodes grass (*Chloris Gayana*) is a fine-stemmed, leafy grass growing to an average height of nearly 3 feet under favorable conditions. It spreads by running branches which root and produce a tuft at every node. It will not withstand winter temperatures below 18° F. Rhodes grass is increasing in popularity as an ingredient of pasture mixtures in the

Palo Verde and Imperial valleys of southeastern California, doubtless because it is quite at home there. Farther north, within its climatic limitations, it is not generally used except in areas that are too alkaline to be tolerated by most other species. On such sites it probably has a real place. Through its ability to absorb alkali salts, however, it may become so saline as to have a scouring effect on livestock. When this is true, the stock should be rotated to other and less purgative feeds.

Bermuda Grass.—A perennial and a native of the warmer portions of the Old World, Bermuda grass (*Cynodon Dactylon*) spreads by both surface runners and underground stems. It is commonly considered as a pest in California and the most common demand is for a mixture that will live with Bermuda rather than for seed of this grass for its own value. This has been discussed elsewhere in this circular. In some interior valleys of San Bernardino County and the Palo Verde and Imperial valleys, Bermuda is far more luxuriant than farther north and has a longer growing season. Graziers there are not generally averse to it for the reason mentioned and the further fact that it has high nutritive values.

Redtop Grass.—A perennial and a native of this country, redtop grass (*Agrostis alba*) has a creeping habit of growth which makes a coarse, loose turf. While it is a wet-land type of grass, it will withstand considerable drought. It is primarily adapted to mountain meadows and pastures but may have a place as a sod-former in seepage areas where it will furnish late feed. Its normal maturity dates are similar to those of timothy.

Timothy.—A perennial, timothy (*Phleum pratense*) is a native of Europe and thus, like redtop grass, a northern species. It is frequently used as a hay and pasture plant in areas of cold winter and moderate summer temperatures. But it has never been durable when used in a mixed pasture in the lower elevations of this state.

COST STUDIES FOR IRRIGATED PASTURE^a

The cost of irrigated pasture may be illustrated by records obtained by the Agricultural Extension Service in conducting pasture-management studies. Table 3 presents averages of the records in three of these studies. These figures are not represented as being average for the counties in which they were obtained but apply only to the particular pastures and years covered by these records. Only mature stands and fairly typical pastures as to stand and use were included in the averages

^a This section was contributed by Arthur Shultis, Extension Specialist in Farm Management.

shown. There was, however, great variation in both costs and use among individual records, with the result that the average of those in Merced County shows much lower use and costs per acre. Differences between study averages might have been reversed with different pastures selected or covered. In order to provide a set of costs typical of a wider range of conditions, a standard based upon probable requirements of labor and materials and with irrigation from an owned pumping plant has been prepared and included in the last column of this table.

TABLE 3

GENERAL SUMMARY OF IRRIGATED PASTURE RECORDS* IN THE SAN JOAQUIN VALLEY, 1936-1940; ALL MATURE STANDS

	Kings County, 1939-1940	Merced County, 1939-1940	Tulare County, 1936-1940	Standard
Total number of annual records.....	10	9	97	....
Total acres covered by records.....	135	3,438	1,004	....
Animal-unit months of pasturage per acre for 1 year .	13.7	6.9	13.0	12.0
Average number of irrigations.....	18	—	17	15
Acre-inches water used per acre (partly estimated)...	70	—	67	60
Costs				
Cost per acre:				
Irrigation labor.....	\$8.24	\$1.73	\$4.07	\$3.00
Other labor.....	1.02	0.68	0.51	1.60
Water cost or power for pumping.....	5.16	2.71	7.14	8.00
Other materials, seed, fertilizer, etc.....	0.00	0.48	0.40	—
General expense and other cash overhead.....	0.72	0.39	0.62	0.63
County taxes.....	1.80	1.35	1.84	2.50
Depreciation on stand, 10 per cent of cost.....	2.00	2.18	2.00	2.00
Depreciation, irrigation system, fences, etc.....	1.33	0.82	3.01	2.75
Total cash and depreciation costs.....	20.27	10.34	19.59	20.48
Interest on average value of stand, 5 per cent.....	0.50	0.54	0.50	0.50
Interest on value of facilities.....	0.61	0.21	1.48	1.25
Interest on value of land.....	7.88	3.34	6.37	10.00
Total cost of production.....	29.26	14.43	27.94	32.23
Cost per animal-unit month.....	2.14	2.09	2.15	2.69
Cost per 100 lbs. total digestible nutrients†.....	0.53	0.52	0.54	0.67
Equivalent value of alfalfa hay per ton at above cost of total digestible nutrients.....	\$5.30	\$5.20	\$5.40	\$6.70

* Averages of a few irrigated-pasture study records obtained by the Agricultural Extension Service in recent years.

† Assuming 1 animal unit month=400 lbs. total digestible nutrients.

Pasturage in the studies referred to above was measured in animal-unit months. The animal-unit month is the pasturage needed for 1

month by 1 cow (or equivalent in feeding needs) getting all of its feed from pasture. This unit was further interpreted as the equivalent of 400 pounds of total digestible nutrients, or the equivalent of 0.8 ton of hay. In computing the production shown in table 3, animals receiving other feed than pasture were proportionately reduced. Also, animals other than mature cattle were converted by means of the following factors:

	Animal units		Animal units
Cattle over 2 years of age.....	1.00	Sheep, mature	0.20
Cattle 1 to 2 years.....	0.75	Lambs, 40 to 100 pounds.....	0.15
Calves, 3 months to 1 year.....	0.50	Horses, mature, light work.....	1.00
Swine, mature	0.50	Horses, 1 to 2 years.....	0.85
Pigs, 40 to 100 pounds.....	0.25	Colts under 1 year.....	0.60
Pigs, 100 to 200 pounds.....	0.40		

Any hay harvested was converted to pasturage at its equivalent feed value and was included in the total production, although costs, aside from mowing, were not included. Some of the pastures were not utilized to full capacity, although where use was much below capacity, the records were not included in the averages.

The cost of establishing a new stand was not studied carefully. Several records showed costs from only a few dollars up to over \$20.00 an acre, depending upon the leveling, checking, and preparation required. With usual land preparation and checking but with little leveling, the cost to bring the stand up to its first use would probably not be much over \$20.00 an acre, including the rental value of the land during the period. For purposes of computing costs for mature stands in table 3, the original cost of the stand in most of the records was estimated at \$20.00 an acre, with an average investment over its lifetime of \$10.00, and with depreciation estimated at \$2.00 a year, or 10 per cent of the estimated cost of securing the stand. Some of the records included were on pastures seeded in old alfalfa fields with almost no tillage or checking.

Records in individual irrigated pastures show ranges in annual costs from \$15.00 to \$40.00 an acre with annual yields of from 5 to 25 animal-unit months of pasturage. Costs per animal-unit month may vary from \$1.00 to \$5.00 but will usually be within the range from \$1.50 to \$3.00. With an animal-unit month estimated as equivalent to 400 pounds of total digestible nutrients, the cost of 100 pounds of these nutrients would be from \$0.38 to \$0.75. To obtain digestible nutrients at this same cost from hay averaging 50 per cent total digestible nutrients, the hay would have to be obtainable at from \$3.80 to \$7.50 a ton. Barley averaging 79 per cent total digestible nutrients could cost only from

\$0.48 to \$0.95 per 100 pounds to be as cheap a source of nutrients as irrigated pasture. On the other hand, prevailing rents and pasturage obtainable on privately owned natural range result in costs as low as \$0.20 to \$0.60 an animal-unit month, or \$0.05 to \$0.15 per 100 pounds of total digestible nutrients. Hence, pasturage from irrigated pastures is usually more expensive than that from natural range, but is a cheaper source of nutrients than most other livestock feeds. It may well be used as a substitute for a considerable proportion of the more expensive feeds on dairy and other livestock farms in the irrigated valleys of California.

CONTROL OF LIVESTOCK PARASITES ON IRRIGATED PASTURES⁷

Irrigated pastures afford a very favorable environment for the free-living stages of certain internal parasites of sheep and cattle. The frequent irrigations keep the soil surface and the bases of the plants moist and at relatively even temperature and thus provide excellent conditions for the development and survival of the immature parasites found in such locations. Then, too, the vegetation protects the parasites from the injurious influences of direct sunlight and drying. The fact that such pastures will successfully carry more animals per unit of area than nonirrigated lands is also of great importance in parasitic infections, since a greater number of immature parasites may be passed in the feces of infected animals onto a given area, and each developing parasite has a very much better chance of ultimately gaining access to an appropriate host.

Finally, a large proportion of the irrigated pasture acreage is utilized for young livestock, and young animals are, in general, much more susceptible to internal parasites than the older ones. Therefore, it must be recognized that irrigated pastures, valuable as they are in livestock raising, intensify problems of parasite control.

Despite this rather dismal picture, livestock raisers can utilize these valuable pastures to great advantage by routinely employing measures which will suppress the parasites and prevent infections sufficiently heavy to affect adversely the health and proper development of their animals.

Coccidiosis.—Coccidiosis is produced in sheep and cattle by the invasion of the intestinal wall by any one of several small single-celled organisms (Protozoa) belonging to the genus *Eimeria*. The free-living infective stages are found on soil and vegetation as a consequence of

⁷ This section was contributed by M. A. Stewart, Associate Professor of Entomology and Associate Entomologist in the Experiment Station.

having been eliminated, in an earlier stage of development, in the feces of an infected animal. These immature parasites require considerable moisture for most rapid growth and development to the infective stage.

Coccidiosis of sheep and cattle, particularly of cattle, appears to be increasing in California, especially in sections where irrigated pastures are common. This apparent increase in the disease can be explained by the very favorable moisture conditions found in the pastures and the increased concentration of stock.

The most constant symptom of coccidiosis is "bloody scours." Although certain other conditions may produce similar symptoms, whenever such scours occur, coccidiosis should be suspected and a definite diagnosis should be made by a competent individual.

There is no chemical treatment definitely known to be satisfactory in the treatment of mammalian coccidiosis. Experience has shown that placing infected animals on dry feed, particularly hay, gives the best results and usually stops the scouring fairly readily. This treatment may, however, merely relieve the symptoms without necessarily curing the infection, and there is need for further research on an effective and safe drug. Coccidiosis may be prevented best, in animals on irrigated pastures, by determining, as far as possible, that animals purchased come from "clean" ranches, and when this is not possible by quarantining new animals, especially young ones, for several days before they are placed on pastures with other stock.

Stomach Worms.—Worms belonging to the genera *Ostertagia*, *Haemonchus*, and *Trichostrongylus* are commonly known as "stomach worms." The *Ostertagia* species are the large stomach worms; the *Trichostrongylus* species are the small, or microscopic, stomach worms; and *Haemonchus contortus* is the twisted wire-worm, or eastern stomach worm. The third species is ordinarily of but little importance in California.

These worms invade the fourth stomach and small intestine of their host. The eggs are eliminated in the feces of the infected host, hatch, pass through a free-living state, then become infective and crawl up on vegetation, where they may be swallowed by a suitable animal. Moisture and protection from direct sunlight and drying are essential for the development of the free-living stages.

Animals infected with stomach worms, in acute cases, scour and become emaciated, weak, and anemic. The diarrheic feces are typically blackish and of particularly foul odor.

Infections with these parasites are especially common and severe in the fall, winter, and spring months. The decrease of infections during

the summer has been shown by Furman,⁸ to be due largely to drying of the immature parasites on the vegetation and to higher temperatures. Furman has also demonstrated that during the summer months more infective larvae are found on the succulent upper leaves of Ladino clover than on alfalfa and more on alfalfa than on Domestic ryegrass, probably because the dense shading growth of Ladino clover gives more protection against drying and high temperatures than do alfalfa and ryegrass. Furthermore, the leaf axils of Ladino do not prevent the immature worms from crawling directly to the higher leaves, which are more readily accessible to the grazing animals, while those of alfalfa act as a partial block and those of ryegrass serve as an even more efficient barrier. The moisture on the surface of the various plants is sufficient during the other months of the year, however, so that there is no significant difference in the number of larvae in the higher leaves on the three vegetation types. From these data it may be concluded that Ladino clover is a more favorable reservoir of stomach-worm infection during the summer months than is alfalfa or western ryegrass. Conditions of temperature and moisture, however, are such that even on Ladino serious infections may be anticipated only during the fall, winter, and spring months; and then there is sufficient moisture on all pasture plants so that there is no significant difference between numbers of parasites on Ladino and on alfalfa or ryegrass.

Stomach-worm infections in sheep and cattle may be successfully treated with cunic mixture, which is made up in the following way:

1. Make a stock solution of 2 pounds of copper sulfate in 1 gallon of water in a wooden or earthenware container.
2. To 1 pint of the above solution, add $11\frac{1}{2}$ quarts of water to make 3 gallons.
3. To this 3 gallons of copper sulfate solution add 4 fluid ounces of 40 per cent nicotine sulfate (Black Leaf 40).
4. Steps 2 and 3 may be repeated as needed. This is a better procedure than mixing the entire quantity at once because the completed mixture deteriorates on standing.

The dosage for a full-grown ewe is 4 fluid ounces, graduated to 2 ounces for lambs 3 months old. Since cattle have a lower tolerance for nicotine, the dosage is $3\frac{1}{2}$ ounces for animals weighing more than 150 pounds. The drug is administered with a drenching syringe. It is recommended that the animals be kept off food and water for 12 hours before treatment and be starved for another 2 hours after treatment.

⁸ Furman, Deane P. A study of the effects of environment upon the free-living stages of *Ostertagia circumcincta* (Stadelmann). Thesis for the degree of Doctor of Philosophy, University of California, 1942. (Typewritten.) Copy on file in the University of California Library, Berkeley.

It is usually most practical to drench the sheep in the morning. If cunic mixture is administered in excessive dosages, fatal poisoning may result. Animals which have been shipped some distance and starved en route should be fed the night before treatment to prevent too great absorption of the drug. Care must be taken during drenching to prevent the solution from getting into the lungs.

Phenothiazine, a recently developed drug, is known to be efficient in killing stomach worms, but this drug should be considered to be still in the experimental stage and, therefore, its widespread use is not warranted at the present time.

Stomach-worm infections on irrigated pastures can be prevented to a large extent by treating all new animals with cunic mixture before they are placed on the pasture and in heavily infected areas by treating the animals every 3 weeks from the time they are 3 weeks old.

Furman (see footnote 8, p. 45) has shown that stomach-worm larvae will remain alive on irrigated pastures sown to Ladino clover or alfalfa for at least 200 days including the summer months and also that the larvae will migrate upward through 12 inches of plowed soil. Plowing followed by a rotation might, however, be of some value.

Nodular Worms.—Parasitic worms belonging to the genus *Oesophagostomum*, known as “nodular worms,” cause a disease which produces symptoms similar to those produced by stomach worms, but in acute cases they may be more serious than the latter. It has been generally considered that these worms become of economic importance only in those regions where summer rains occur. Recently, however, nodular worms have been observed to be causing some deaths in deer in several parts of central and northern California. It should be recognized that the moisture conditions of irrigated pastures may permit the establishment of nodular-worm infections in California in serious proportions, and sooner or later this parasite may become a serious problem on irrigated pastures.

The only treatment that is known to be effective against nodular-worm infections is the recently developed drug, phenothiazine, mentioned in the section on stomach worms. This chemical is administered at the rate of 0.4 gram per pound of body weight.

Liver Flukes.—To our knowledge, there is no recorded instance in which liver-fluke (*Fasciola hepatica*) infection was acquired on irrigated pastures in California. Still it is possible that appropriate intermediate snail hosts may occur on such pastures and that liver-fluke infections consequently may become established. The chief danger of such an occurrence lies in the possibility that a snail-host population may

build up in the irrigation ditches and that the immature flukes, escaping from the snails, may be transported to the vegetation during irrigation. The reader is referred to Bulletin 603⁹ for further information on liver flukes.

⁹ Freeborn, Stanley B., and Morris A. Stewart. The nematodes and certain other parasites of sheep. California Agr. Exp. Sta. Bul. 603:1-75. 1937.

